Quarterly Report
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Abstract

Our major achievements of this quarter were: (i) the upgrade of the MODIS Airborne Simulator (MAS) and radiometric characterization in a thermal/vacuum chamber, (ii) the analysis of MAS instrument data acquired in the thermal/vacuum chamber, to be used in temperature corrections for in-flight and ground calibrations, (iii) preparation for an April cirrus cloud deployment known as SUCCESS (Subsonic Aircraft Contrail and Cloud Effects Special Study), which includes a quick-look data processing system for use in the field, and (iv) the improvement of the efficiency of our MODIS cloud retrieval algorithms.

I. Task Objectives

With the use of related airborne instrumentation, such as the MODIS Airborne Simulator (MAS) and Cloud Absorption Radiometer (CAR) in intensive field experiments, our primary objective is to extend and expand algorithms for retrieving the optical thickness and effective radius of clouds from radiation measurements to be obtained from the Moderate Resolution Imaging Spectroradiometer (MODIS). The secondary objective is to obtain an enhanced knowledge of surface angular and spectral properties that can be inferred from airborne directional radiance measurements.

II. Work Accomplished

a. MODIS-related Instrumental Research

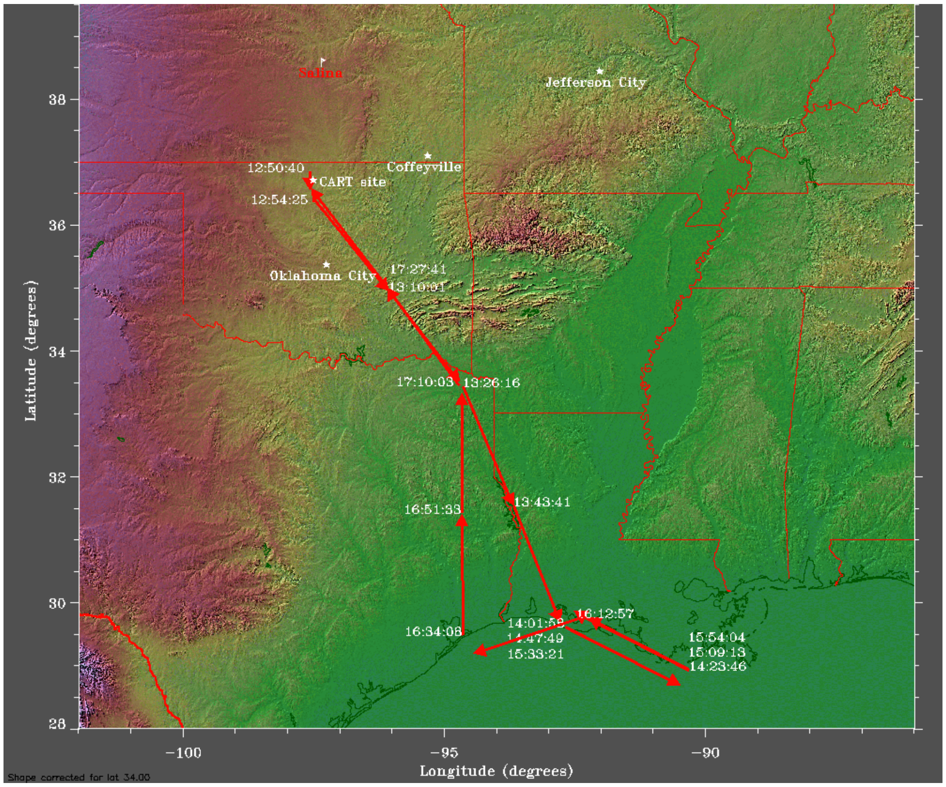
The MAS returned from Dædalus on March 3rd with many modifications and improvements. On the MAS optics: (i) both mirrors in the Pfund assembly (field stop) were re-coated and re-aligned; (ii) all seven spectrometer mirrors were re-coated; (iii) the first and second dichroics were replaced; (iv) the port 2 grating was replaced (the port 1 grating was determined to be working properly, and was not replaced); (v) a new primary folding mirror and a new primary parabola were installed (the old ones were re-coated as spare parts); and (vi) the rotating scan mirror was re-coated. On the MAS electronics: (i) heaters were added to the outside of the port 2 pre-amplifier housing and thermostatically controlled to maintain a temperature of 28° C (± 1°) inside the housing (cold test by Dædalus down to -30°C); (ii) this pre-amplifier housing was also thermally isolated from the dewar jacket to prevent uneven heating of the dewar; (iii) the port 1 detector array is now temperature stabilized to 29°C (± 1°) and was cold tested down to -

30°C (the blue channel is not yet installed); (iv) the port 2 pre-amplifier was repaired and the gains for channels 10, 16, 19, 20 were lowered to match the rest of the array; (v) the amplifiers for channels 10-13 were replaced; and (vi) the voltage regulator that supplies all the pre-amplifiers, and some related connectors, was replaced (this might have been the source of the port 4 transients that occurred during and after the Brazil deployment).

As a result of these MAS upgrades, Dædalus reported that signal levels have increased, on an average of 132% for port 1, 51% for port 2, and 112% for port 3 (port 4 was not measured due to lack of time, but a big improvement is expected). The "TEMP2" thermistor was found to be physically detached from its location on the port 3 optics housing; making its data meaningless. This may have happened around the time of the GSFC chamber tests, but there is no way of knowing for sure. Several of the heater control thermistors were also detached, which means the head heaters were not being properly regulated. These have all been re-attached with a new type of epoxy. Two more new "TEMP" values will be added to the MAS housekeeping (inside of the port 2 pre-amplifier housing and port 1 array mount). Aerodynamic modeling of the cavity in the rear of the ER-2 superpod, where the MAS head is mounted, shows a sizable air blast. This undoubtedly increases cooling of the head and probably explains some of the incongruities in the Goddard chamber tests (possibly some thermal IR calibration errors as well). A strake (air dam) has been designed to fit in front of the MAS aperture on the superpod to reduce the airflow inside the cavity. This will be installed before the SUCCESS deployment. The MAS head will have eight additional thermistors installed for the first test flight to record the results.

During the week of March 18-24, Tom Arnold, Steve Platnick and NASA Ames personnel conducted four cold chamber tests on the MAS, three with heaters on and one off. Preliminary analyses of tests 1-3, and comparing to previous chamber calibration work at Goddard, show that the thermal sensitivity of ports 1 and 2 calibration is reduced significantly (to less than 5%) after the MAS upgrades. However, the calibration changes as a function of temperature are more complex. More testings are needed to check the repeatability and to simulate various flight temperature regimes in the chamber.

To further support our scientists in future field campaign, Ward Meyer and Jason Li have developed a self-contained hardware and software package for the SGI (redback) workstation in MAS deployment. In collaboration with scientists at the University of Wisconsin - Madison, an IDL routine package was created to produce quick-look products from MAS data after each flight. Unlike the quick-look procedure developed earlier, the new one presents MAS data for multispectral bands in compact GIF files and the ER-2 flight track is overlaid over a fine resolution of topographic map with time codes along the aircraft ground track. This will be an integral part of quick-look products for the upcoming SUCCESS field campaign (see example below, from 9 April 1996).



The MAS 50-channel Level-1B processing software has been completed by Paul Hubanks. After discussions with Jeff Myers and Mike Fitzgerald at NASA Ames Research Center, we found that the subtraction of a 3000 count offset from the recorded cold blackbody counts during the visible and near-infrared calibration procedure is not necessary. In addition, the emissivity correction for infrared calibration developed by Chris Moeller requires the unpacking of the scan head count from the Level-0 data. These correction schemes have been implemented and will be applied to the re-processing of Level-1B data from the ARMCAS (June, 1995 in Alaska) and SCAR-B (August-September, 1995 in Brazil) campaigns.

The post SCAR-B calibration of the CAR was conducted by Tom Arnold using the 48-inch integrating hemisphere as the source. Due to some apparent changes in the actual output of both 48-inch and 6-foot Goddard integrating sources, as pointed out by John Cooper, it is not obvious how to choose a proper source calibration to apply to the CAR data sets. Since the CAR viewed both sources for most calibrations, detailed intercomparisions are required. Reprocessing is now underway for of all pre- and post-deployment MAST (June, 1994), SCAR-C (September, 1994), ARMCAS (June, 1995), and SCAR-B (August-September, 1995) calibration data using all possible sources.

b. MODIS-related Data Processing and Algorithm Study

When analyzing a large volume of remote sensing data, such as those acquired from the hyperspectral and high spatial resolution MAS, visualization tools are of vital importance to scientists. Working closely with Dr. Fritz Hasler's group, Jason Li recently ported the Interactive Image SpreadSheet (IISS) software to both SGI computers in the cloud retrieval group (redback and cerpa). Another commercial image processing package (ENVI), developed and promoted by NASA Ames, was also installed on these computers. Measurements obtained from MAS (8/18, 8/25, 9/1 for fires, smoke, and aerosol-cloud interaction), CAR (9/18 for whole-surface imagery) and GOES-8 (8/25) sensors were demonstrated using both IISS and ENVI tools at the SCAR-B science meeting, held recently at Goddard. Both packages exhibit strong capabilities in the area of image visualizations and analysis.

The MAS thermal/vacuum chamber data collected at Goddard last November were analyzed by Steve Platnick and Tom Arnold. A set of fitting functions was developed, both for warm and cold tests, that, taken together, can be used to approximate the instrument gain changes for any in-flight temperature and any ground calibration temperature. These fitting functions, together with emissivity corrections, were used by Paul Hubanks to process MAST Level-1B data. Running both new Level-1B and the original data through our cloud retrieval algorithms, Steve Platnick concluded that the latest processing provides more reasonable retrieval results than the initial results obtained without the proper instrument thermal adjustments applied to the calibration coefficients.

Steve also implemented and integrated the correlated k-distribution method to create a single code. For a given standard atmosphere or MAST sounding, this code calculates the above-cloud atmospheric transmittance and emittance (if appropriate) for MAS channels 2, 7, 10, 20, 23, 31, 32, 44, and 45. This code also does a three-variable fit to the transmittance and emittance in each band as a function of the cosine of the zenith angle. These fits are later used in Platnick's cloud retrieval code for atmospheric corrections. Six days of AVHRR imagery, including in-track and out-of-track data during the MAST experiment, were provided by the Naval Postgraduate School. Results from analyzing MAS and these AVHRR data are currently in preparation for a journal article.

After the delivery of our MODIS Beta-3 cloud retrieval algorithm software for integration and testing, Menghua Wang further improved the efficiency of the retrieval code. This was done by generating new lookup tables, modifying/rewriting, and creating/replacing subroutines in the cloud retrieval code. The efficiency of the cloud retrieval algorithm has been improved by a factor of more than 6, as shown in the following results. CPU times for 1 scancube of MODIS data (there are 100 scan cubes in a granule) are:

Compiler option	*Before*	*After*
Without optimization	183 s	25.8 s
With optimization	111 s	17.5 s

The inclusion of the 3.7 µm channel into the present MODIS cloud retrieval algorithm (0.66, 1.6 and 2.1 µm) is currently underway. Reflectance lookup tables for 0.66, 1.6, 2.1, 3.7, and 11 µm channels in MODIS data format have been generated. We intend to use these as deliverable lookup tables for integrated code in the MODIS *v1* cloud retrieval algorithm delivery. In April, we will first deliver our current code (0.66, 1.6 and 2.1 µm) with the efficiency improved as indicated above, but with new table lookups. We intend to re-deliver the integrated code (0.66, 1.6, 2.1, 3.7 and 11 µm) to SDST in June.

More simulations of CAR measurements using both discrete-ordinate (DisORT) and backward Monte Carlo radiative transfer codes were conducted by Robert Pincus to investigate cloud properties in the diffusion domain. The primary focus is on evaluating the amount of numerical noise in Monte Carlo computations by computing the radiance field inside a homogeneous cloud. It has been found that the algorithm used to identify the diffusion domain is quite sensitive to the zenith and nadir radiances. To accelerate the investigation, various plotting tools have been created. For example, with the help of Jason Li, the cross-correlation coefficients can be examined in a 4-D space using an IDL shade volume technique.

c. MODIS-related Services

1. Meetings

1. Si-Chee Tsay attended the US-Japan Workshop on Arctic Research, held in Fairbanks, Alaska on 5-8 February 1996 and presented a NASA/MTPE EOS-MODIS description of radiation measurements in the Arctic;

2. Michael King and Si-Chee Tsay attended the FIRE science team meeting in Williamsburg, Virginia on 13-15 February 1996 and presented an update on EOS as well as preliminary results acquired during the ARMCAS campaign;

3. Michael King attended the NPOESS Workshop at the University of Maryland on 27-29 February 1996 and participated in the Integrating Panel (Jerry Mahlman, chair) discussions on the NPOESS program in light of developments, plans, and capabilities being developed and planned as part of EOS;

4. Michael King, Steve Platnick, Si-Chee Tsay and Menghua Wang attended the CERES science team meeting held at NASA Goddard Space Flight Center on 13-15 March 1996, and Steve presented results analyzed from the CERES AVHRR test data for the retrieval of cloud radiative and microphysical properties;

5. Si-Chee Tsay attended the TARFOX planning meeting at NASA Wallops Flight Facility on 18-20 March 1996 and presented MAS and CAR instrumentation and preliminary results acquired during the SCAR-B campaign;

6. Michael King, Qiang Ji, Jason Li and Si-Chee Tsay attended the SCAR-B

data workshop at NASA Goddard Space Flight Center on 21-22 March 1996 and presented preliminary results of aerosol, CCN, and radiation measurements acquired during the SCAR-B campaign;

2. Seminars

None

III. Anticipated Activities During the Next Quarter

a. Continue to analyze MAS data obtained from the MAST field campaign and prepare articles for journal publications;

b. Continue to work on MODIS *v1* cloud retrieval algorithm delivery;

c. Continue to analyze MAS, AVIRIS, and CLS data gathered during the ARMCAS campaign, as well as AVHRR, University of Washington C-131A in situ data, and surface data, all with the express purpose of helping to develop the MODIS cloud masking algorithm;

d. Continue to analyze MAS, AVIRIS, and CLS data gathered during the US-Brazil SCAR-B campaign, as well as University of Washington C-131A in situ and radiation data to study aerosol-cloud interactions;

e. Continue to analyze surface bidirectional reflectance measurements obtained by the CAR during the Kuwait Oil Fire, LEADEX, ASTEX, SCAR-A ARMCAS, and SCAR-B experiments, as well as analyze CAR diffusion domain data from MAST and FIRE-87;

f. Prepare for and participate in the NASA SUCCESS field experiment in Kansas from 8 April to 10 May 1996;

g. Attend the Aerosol Workshop in Washington, DC and the ONR/MAST science team meeting in Monterey, CA, both during the week of 15-19 April 1996;

h. Attend the MODIS science team meeting (1-3 May 1996), EOS Validation workshop (6-8 May 1996), and Investigators Working Group meeting (13-15 May 1996), all in Greenbelt, MD.

IV. Problems/Corrective Actions

No problems that we are aware of at this time.

V. Publications

1. King, M. D., and M. K. Hobish, 1996: Satellite instrumentation and imagery. *Encyclopedia of Climate and Weather*, Oxford University Press, xx–yy.

2. King, M. D., W. P. Menzel, P. S. Grant, J. S. Myers, G. T. Arnold, S. E. Platnick, L. E. Gumley, S. C. Tsay, C. C. Moeller, M. Fitzgerald, K. S. Brown and F. G. Osterwisch, 1996: Airborne scanning spectrometer for remote sensing of cloud, aerosol, water vapor and surface properties. *J. Atmos. Oceanic Technol.*, in press.

3. Tsay, S. C., P. M. Gabriel, M. D. King and G. L. Stephens, 1996: Spectral reflectance and atmospheric energetics in cirrus-like clouds. Part II: Applications of a Fourier-Riccati approach to radiative transfer. *J. Atmos. Sci.*, in press.